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UTILITY PATENT APPLICATION TRANSMITTAL

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Attorney Docket No.	042390.P6518
First Inventor or Application Identifier	Susan C. Kromenaker
Title	RETRIEVING I/O PROCESSOR PERFORMANCE MONITOR DATA
Express Mail Label No.	EM522828818US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents

ADDRESS TO: Assistant Commissioner for Patents
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1. [X] Fee Transmittal Form *(Submit an original, and a duplicate for fee processing)*
2. [X] Specification *Total Pages* 32 *(preferred arrangement set forth below)*
   - Descriptive title of the Invention
   - Cross References to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to Microfiche Appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings (*if filed*)
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
3. [X] Drawing(s) *(35 CFR 113)* *Total Sheets* 4
4. Oath or Declaration *Total Pages* 3
   a. [X] Newly executed (original copy)
   b. [ ] Copy from a prior application (37 CFR 1.63(d)) *(for continuation/divisional with Box 16 completed)* ***[Note Box 5 below]***
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).

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5. [ ] Microfiche Computer Program *(Appendix)*
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ACCOMPANYING APPLICATION PARTS

7. [X] Assignment Papers (cover sheet & document(s))
8. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
9. [ ] English Translation Document *(if applicable)*
10. [ ] Information Disclosure Statement (IDS)/PTO - 1449 [ ] Copies of IDS Citations
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17. CORRESPONDENCE ADDRESS

[ ] *Customer Number of Bar Code Label* *(Insert Customer No. or Attach bare code label here)* or [X] *Correspondence address below*

Name	BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP				
Address	12400 Wilshire Boulevard, Seventh Floor				
City	Los Angeles	*State*	California	*Zip Code*	90025
Country	U.S.A.	*Telephone*	(310) 207-3800	*Fax*	(310) 820-5988

Name (Print/Type)	Vincent P. Tassinari, Reg. No. 42,179		
Signature		*Date*	09/30/99

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Attorney Docket No. 042390.P6518
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UNITED STATES PATENT APPLICATION

FOR

RETRIEVING I/O PROCESSOR PERFORMANCE MONITOR DATA

Inventor(s):

Susan C. KROMENAKER
Mark L. BROWN
Linda M. ROBERTS
William C. ARTHUR, JR.

Prepared by:

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN
12400 Wilshire Boulevard
Seventh Floor
Los Angeles, California 90025-1026
(310) 207-3800

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to computer system architecture. More specifically, the present invention relates to retrieving performance monitor data from an I/O processor.

2. Background Information

Electronic products may be thought of as those products that involve the controlled conduction of electrons or other charge carriers, especially through microprocessors. Examples of electronic products include radios, computers, work stations, and servers as well as those involved in high-end networking and storage technology. Just about all electronic products employ one or more microprocessors disposed within a chip located on a printed circuit board. These microprocessors engage a computer operating system as well as applications. The main central processing unit within the chip includes a host system. It is this host system that runs the computer operating system and the applications.

One type of processor within the host system is a host processor having a host memory. Another type of processor that may be within the host system is an inpur-output (I/O) processor. The I/O processor or I/O Platform (IOP) is a component of the host system that connects the host system memory to an I/O device to process I/O transactions. The I/O device may be a part of or external to the host system through at least one of a primary bus and a secondary bus. Examples of I/O devices include storage

devices such as a small computer systems interface (SCSI) controller for a disk and networking devices such as an Ethernet controller.

One main function of a host system is to transmit data between the host memory and an I/O device via the I/O processor. Transmitted data includes application data, local area network (LAN) packets, and contents stored on a disk. To accomplish data transmission, data handling and processing units such as a core processor and a local memory are included within the I/O processor. The core processor and the local memory are coupled to each other through an internal bus and to a messaging unit and a direct memory access unit through that same internal bus. Ideally, the system performs within established parameters.

To measure and monitor various system parameters that contribute to the overall performance of the I/O processor, a performance monitoring unit is integrated into the I/O processor. Under current standards, the tasks of the performance monitoring unit include compiling performance measurements on the three buses: the primary bus; the secondary bus; and the internal bus. The measurements of the performance monitoring unit can be used to refine code for improved system level performance. However, these measurements exist in raw, binary data for which no mechanism exists that gathers and compiles this raw, I/O performance monitor data into a form that readily is usable by a computer programmer or operator.

SUMMARY OF THE INVENTION

The present invention relates to retrieving performance monitor data from an I/O processor. A performance monitoring driver coupled to a performance monitoring unit is registered as a private driver with a real time operating system of the I/O processor. Events within the I/O processor are selected on which to gather data. The selected events are sent as a message request to the real time operating system. The message request is translated into the appropriate parameters based on a set of private group parameters that are accessible by the real time operating system. The message request is sent as a translated request to the performance monitoring unit. The pieces of data requested by the translated request are returned to the performance monitoring driver. The pieces of data then are sent to a location specified in the message request.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a functional block diagram of an I/O processor;

Figure 2 is a block diagram of a networking system 200;

Figure 3 illustrates a more detailed view of a host processor and an I/O processor; and

Figure 4 is a flow diagram of a method of operation 500 of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Figure 1 is a functional block diagram of I/O processor 10. An example of a known processor functional block diagram is illustrated and described for the Intel® i960® RM/RP Microprocessor as set out in Intel Corporation, *i960® RM/RN I/O Processor Developer's Manual*, pp. 1-1 through 1-12 (1st ed. July 1998). The description regarding **Figure 1** is based on the Intel® i960® RM/RP Microprocessor.

As show in **Figure 1**, I/O processor 10 integrates core processor 14 into a Peripheral Components Interconnect (PCI) functionality so as to address the needs of intelligent input-output applications ("intelligent I/O" or "I_2O" applications). Intelligent I/O applications may be coupled to primary PCI bus 16 and/or secondary PCI bus 18. Preferably both PCI bus 16 and PCI bus 18 are industry standard, 64-bit/32-bit, high performance, low latency system buses coupled together by PCI-to-PCI bridge 20. A specification for the PCI bus is set forth in the document *PCI Local Bus Specification*, revision 2.1, October, 1994. This manual is prepared and maintained by the PCI Special Interest Group (PCI-SIG). The PCI-SIG is an organization that is open for membership to all companies in the computer industry.

Along with providing a connection path between the two independent PCI buses 16 and 18, bridge 20 provides the ability to overcome PCI electrical loading limits by allowing certain bus transactions on one PCI bus to be forwarded to the other PCI bus. Core processor 14 is indirectly connected to PCI-to-PCI bridge 20.

Bus interface unit 24 couples core processor 14 to internal bus 26. In turn, internal bus 26 is coupled to primary transfer group 28 and secondary transfer group 30. Internal bus 26 may be a 64-bit bus. PCI-to-PCI bridge 20 is coupled to primary transfer group 28 through primary PCI bus 16 and is coupled to secondary transfer group 30 through secondary PCI group 18, each path of which provides a link to core processor 14. By communicatively connecting core processor 14 to bridge 20, core processor 14 gives intelligence to bridge 20 to better address the needs of intelligent I/O applications coupled to primary PCI bus 16 and/or secondary PCI bus 18.

PCI agents 100 may be coupled to either primary PCI bus 16 or secondary PCI bus 18 so as to interact with one of the transfer groups, 28 and 30. PCI agents 100 may include external PCI devices or a host processor, such as host processor 240. Within PCI agent 100 may be PCI memory having PCI address spaces.

Internal bus 26 may be coupled to local memory 38 through memory controller 40. Local memory 38 includes memory systems external to I/O processor 10 that do not require external logic. Examples of local memory 38 include Synchronous Dynamic Random Access Memory (SDRAM), Read-Only Memory (ROM), and Flash memory.

Primary transfer group 28 preferably is composed of Address Translation Unit 32, two Direct Memory Access channels 34, and messaging unit 36. Secondary transfer group 30 preferably is composed of Address Translation Unit 42 and One DMA channel 44.

Address Translation Unit (ATU) 32 allows transactions between the PCI address space within PCI agent (or "agents") 100 and

address space 46 within local memory 38. Address translation may be controlled through programmable registers (not shown) that are accessible from both PCI agent 100 and core processor 14. ATU 42 functions similarly to ATU 32, but performs on secondary PCI bus 18 for PCI agents 100 coupled to secondary PCI bus 18. Dual access to registers through ATU 32 and ATU 42 allows flexibility in mapping the coupled address spaces.

To insure low latency and high throughput data transfers between PCI agents 100 and local memory 38, three separate DMA channels are provided as shown in **Figure 1**. Two Direct Memory Access (DMA) channels 34 are included with primary transfer group 28 and one DMA channel 44 is included with secondary transfer group 30. The three DMA channels operate as a DMA controller to support chaining and unaligned data transfers. This DMA controller is only programmable through core processor 14.

The I_2O Architecture Specification describes an open architecture for developing device drivers in a system environment. Conventionally, based on the I_2O Architecture Specification, messaging unit (MU) 36 provides data transfer between PCI agents 100 coupled to primary PCI bus 16 and core processor 14. MU 36 can be used to send and receive messages. Moreover, MU 36 interrupts PCI bus agents 100 or core processor 14 when new data arrives and passes the data as directed.

Core processor 14 is interfaced with internal bus 26 through bus interface unit 24. Local memory 38 is coupled to internal bus 26 through memory controller unit 40. Microcontrollers 56 are interfaced with internal bus 26 through the series of Inter-

Integrated Circuit (I^2C) serial bus 50 and I^2C bus interface unit 52. Both local memory 38 and microcontrollers 56 are external to I/O processor 10. Application accelerator unit 54 is also coupled to internal bus 26.

Memory controller 40 allows direct control of local memory 38. Core processor 14 operates out of local memory 38 where this memory space is independent of PCI agents 100. Bus interface unit (BIU) 24 forwards accesses to core processor 14 to internal bus 26 without translation. Microcontrollers 56 perform management functions for the systems of I/O processor 10. Application accelerator unit (AAU) 54 executes data transfers to and from local memory 38 on behalf of core processor 14 as set out for the I_2O standard.

I/O processor 10 also includes internal arbitration unit 60 to serve as arbiter for the systems of internal bus 26, secondary PCI arbitration unit 62 to serve as arbiter for the secondary PCI bus 18, and performance monitoring unit (PMON) 64.

As noted above, performance monitoring unit (PMON) 64 may be used to compile performance measurements on the three buses: primary PCI bus 16, secondary PCI bus 18, and internal bus 26. The compiled measurements of PMON 64 can be used for performance analysis or real-time system tuning by refining code for improved system level performance.

Within the I_2O Architecture, data is stored in parameter groups on I/O processor 10 such as in local memory 38. Data in local memory 38 may be modified or extracted by host processor 240 through a message sent by host processor 240 to I/O processor 10.

However, the I_2O Architecture does not provide any mechanism for gathering performance measurements compiled by PMON 64. The below embodiments of the invention extend the I_2O Architecture to provide this capability.

Figure 2 is a block diagram of networking system 200. Networking 200 includes client 300 coupled to client 400 through host system 230. Host system 230 may include host processor 240 coupled to I/O processor 210 through host system or PCI bus 250. Within host system 230 is I/O device 260 interfaced with I/O processor 210. Network lines 402 are coupled to I/O device 260.

Client 300 may be a computer that includes data input devices such as keyboard 302 and mouse 304 and includes visual monitor 306. Preferably, host system 230 physically is part of client 300, but may be remote from client 300. For example, client 300 may be in one location and host system 230 may be in another location, but connected via communication channels 308 such as radio signals, cabling, or the Internet.

As one example of networking system 200, host system 230 may be connected to client 400 through network lines 402. Network lines 402 may be any form of communication channel over which data from host system 230 may be transmitted to client 400. Client 400 may be composed of one computer or millions of computers.

Figure 3 illustrates a more detailed view of host processor 240 and I/O processor 210. Within host processor 240 is an Operating System Specific Module (OSM) 300. Preferably, OSM 300 is the host process software for the I_2O architecture. OSM 300 is coupled to Real Time Operating System (RTOS) 302. The software of

RTOS 302 abstracts a large portion of I/O processor 210 hardware from the rest of the software that runs on I/O processor 210. By permitting common commands to enable applications within I/O processor 210, RTOS 302 permits a programmer to develop a driver for one I/O device and get the driver running on one or many different I/O processors with minimal effort.

Conventionally, drivers are used to couple devices external to I/O processor 210. As shown in **Figure 3**, Small Computer System interface (SCSI) device driver 312 couples SCSI controller 310 to RTOS 302 as an example of a storage device. Networking 402, as coupled to Ethernet 410, is coupled to RTOS 302 through networking driver 314 as an example of a networking device.

RTOS 302 aids in message passing between the external devices and OSM 300. By conceptually treating PMON unit 64 as a device external to I/O processor 210, the invention takes advantage of message passing features of RTOS 302 by coupling PMON unit 64 to RTOS 302 through PMON driver 320. PMON driver 320 is a Device Driver Module (DDM) dedicated to performance (perf) monitoring resources and may be referred to as "perfDDM". PMON driver 320 may operate by itself or work in conjunction with either a storage device or a networking device.

The system management interface of the I_2O Architecture Specification provides for developing private parameter groups. Private parameter groups reside in the I/O processor memory. An Operating System Specific Module may be used to gather data from a driver. For example, private parameter groups of the invention preferably reside in the I/O processor memory and OSM 300 may be

used to gather data from PMON driver 320 of **Figure 3**.

Each parameter group may include a group number, a group type, a group name, a description of the group, and includes one or more parameters belonging to the group. A parameter may be identified by a field number, whether the parameter is readable or writable, the file size of the parameter, the parameter name, and a description of the parameter. In one embodiment of the invention, three private parameter groups contain a total of thirty one fields reside as software in memory 38 of I/O processor 210.

Within performance monitoring Table 1, Table 2, and Table 3 below are a set of parameter groups that define an embodiment of the invention. Table 1 is the Control Group, Table 2 is the Mode Control Group and Table 3 is the Mode Data Group. The contents of the parameter groups include the performance monitor data and performance monitor setup information. Software running on host processor 240 can gather or modify one or more parameters stored in these parameter groups.

Table 1 Performance Monitoring Control Group 0x8000x

Group Number Group Type Name Description		0x8000x SCALAR PERFMON_CONTROL A table of all control parameters for hardware-based performance monitoring resources		
Field Idx	(r/w)	Field Size	Parameter Name	Description
0	r/w	5 Bytes	LockControl	Bytes 0-3 are the AuthenticationKey. When the LockControl field is read by an application and the Locked bit is not set, the initiator Target Identification (TID) from the UtilGetParams message is saved, a unique AuthenticationKey is returned in these bytes of the field, and the Locked bit is tentatively changed to the set state. The application then has 2 seconds to lock the performance monitoring resources by sending a UtilParamsSet message with the proper TID to write to the LockControl field with the Locked bit set and the proper AuthenticationKey in Bytes 0-3. When this occurs, the resources remain locked, if they are currently unlocked. Otherwise, after the 2 second timeout period runs out, the locked bit is reset and other applications can attempt to lock the resources. During the 2 second backoff period, other applications that read the LockedControl field will detect that the resources are already locked, and the AuthenticationKey will be set to something other than the proper one.
1	r/w	11 Bytes	Control	Bit 0 of byte 4 is the Locked bit. For the Locked bit, 1 means locked and 0 means unlocked. When this bit is set along with a proper AuthenticationKey, the perfDDM saves the initiator TID, fields from the UtilParamsSet message. Every subsequent UtilParamsSet or UtilParamsGet message with an

Table 1 cont. Performance Monitoring Control Group 0x8000x

Group Number Group Type Name Description		0x8000x SCALAR PERFMON_CONTROL A table of all control parameters for hardware-based performance monitoring resources		
Fieldl dx	(r/w)	Field Size	Parameter Name	Description
1 cont.	r/w	11 Bytes	Control	initiator TID field equal to the saved TID value causes a watchdog timer to be zeroed. After 5 min., if no UtilParamsGet or UtilParamsSet messages to the perfDDM parameter groups with the initiator TID field equal to the saved value are received, then the locked state bit is cleared. This mechanism mediates resource contention between applications and DDMs under development, while preventing resource lockout due to halted applications. Default is unlocked(0). NOTE: Because of the 2 second timeout condition, spurious UtilGetParams messages that read the LockControl field should be avoided, since these reads would prevent other applications from being able to lock the performance monitoring resources during the backoff period. Bytes 0-3 contain the AuthenticationKey. The AuthenticationKey verifys that the configuration host application that is attempting to alter the is the one that locked the resources. On writes, this key must be equal to the last authentication key issued by the perfDDM. If equal, the host application's UtilParamsSet message will be processed normally. If not equal to the last issued authentication key, then the UtilSetParams reply message indicates an error. On reads this field returns 0.

Table 1 cont. Performance Monitoring Control Group 0x8000x

Group Number Group Type Name Description		0x8000x SCALAR PERFMON_CONTROL A table of all control parameters for hardware-based performance monitoring resources		
Fieldl dx	(r/w)	Field Size	Parameter Name	Description
1 cont.	r/w	11 Bytes	Control	Bit 0 of byte 4 is the Accumulate count bit. For the Accumulate count bit, 0 means only report deltas for last interval and 1 means accumulate counters and time intervals. Default is Accumulate counters and time intervals(1). Bit 1 of byte 4 is the Counting_On bit. The Counting_On bit gives the application a quick way to turn off counting in the performance monitor. This will be used to limit the impact of performance monitoring-related bus accesses on the counter statistics reported. When an application wants to turn counting off, it will send the smallest UtilParamsSet message possible to access only this field. When counting is turned ON, the saved counter values for each mode are zeroed out. Default is counting off. Note: when Counting_On is 1, all writes to any other parameter group fields or bits than Counting_ON are disallowed. An error will be returned for such accesses. Note: when Counting_On is 0 and all the ModelInterval fields for all modes are set to 0 (see group 0x8001, field #1 below), counting cannot be turned on, since no modes

Table 1 cont. Performance Monitoring Control Group 0x8000x

Group Number Group Type Name Description		0x8000x SCALAR PERFMON_CONTROL A table of all control parameters for hardware-based performance monitoring resources		
Fieldl dx	(r/w)	Field Size	Parameter Name	Description
1 cont.	r/w	11 Bytes	Control	have been allocated counting intervals. Attempts to set Counting_On in this case will result in an 120_PARAMS_STATUS_SCALAR_ERROR being returned by the operation. Bit 2 of byte 4 is the GlobalSendOnCycleEnd bit. If bit 2 is set, the EventData fields of Event Acknowledge Messages for the CYCLE_END event will contain selected rows of the PERFMON_MODE_DATA table group. If this bit is reset, Event Acknowledge messages contain no EventData. Default is reset. Bit 3 of byte 4 is the Pause bit. The Pause bit can be used to temporarily disable counting and subsequently reenable counting without zeroing the saved counter values for each mode. Default is OFF. Byte 5 is the CurrAlgorithm The CurrAlgorithm is used to set the sampling algorithm. Initially, there will be two sampling algorithms supported: User-configurable simple round-robin(0), and distributed round-robin(1). Default: distributed round-robin. Bit 2 of byte 4 is the GlobalSendOnCycleEnd bit. If bit 2 is set, the EventData fields of Event Acknowledge Messages for the CYCLE_END event will contain selected rows of the PERFMON_MODE_DATA table group. If

Table 1 cont. Performance Monitoring Control Group 0x8000x

Group Number	0x8000x		
Group Type	SCALAR		
Name	PERFMON_CONTROL		
Description	A table of all control parameters for hardware-based performance monitoring resources		
Fieldldx	(r/w)	Field Size	Parameter Name	Description
1 cont.	r/w	11 Bytes	Control	this bit is reset, Event Acknowledge messages contain no EventData. Default is reset. Bit 3 of byte 4 is the Pause bit. The Pause bit can be used to temporarily disable counting and subsequently reenable counting without zeroing the saved counter values for each mode. Default is OFF. Byte 5 is the CurrAlgorithm The CurrAlgorithm is used to set the sampling algorithm. Initially, there will be two sampling algorithms supported: User-configurable simple round-robin(0), and distributed round-robin(1). Default: distributed round-robin. Byte 6 is the SampleUnits. The SampleUnits specifies the units for the selected sample interval: usec(0), msec(1), sec(2), min(3). Default: msec. Bytes 7 through 10 are the SampleInterval; which specifies the number of SampleUnits in the selected sample interval. Default: 100, giving a default sample interval of 100 msec. If the users select as a sample interval less than the minimum sample interval, the actual sample interval is rounded up. The largest sample interval supported is 71 minutes.

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Table 1 cont. Performance Monitoring Control Group 0x8000x

Group Number Group Type Name Description		0x8000x SCALAR PERFMON_CONTROL A table of all control parameters for hardware-based performance monitoring resources		
Fieldldx	(r/w)	Field Size	Parameter Name	Description
2	r	1 Byte	MaxMode	Maximum # of modes for the performance monitoring resources. DDMs use this to indicate the number of modes supported by the underlying hardware. Typically these are hardware modes.
3	r	1 Byte	CurrentMode	Current mode of the performance monitoring resources. This is used for debugging purposes.
4	r	1 Byte	MaxAlgorithm	Maximum # of sample algorithms. DDMs can use this to indicate the number of algorithms that can be supported. Sample algorithms are software-controlled.
5	r	1 Byte	MinSampleUnits	Specifies the units for the minimum supported sample interval: usec(0), msec(1), sec(2), min(3). This value will be determined by the resolution of the RTOS event timer.
6	r	4 Bytes	MinSampleInterval	Number of MinSampleUnits in the minimum supported sample interval. This value will be determined by the resolution of the RTOS system timer rounded to the nearest microsecond.
7	r	1 Byte	PerfHWType	Type of performance monitoring hardware available: -0 means NONE, 1 means i960 RN or RM, all other values are reserved.
11	r	1 Byte	NumCounters	Number of performance monitor counters supported by hardware.
13	r	1 Byte	SampleInterval Status	Provides an indicator of whether the user-selected sample interval is okay(0), too small(1), or too large(2), adjusted(3).
14	r	4 Bytes	AdjustedSample Interval	Displays the rounded up sample interval, e.g. the user-configured sample interval rounded up to the next integer multiple of the system timer resolution.

Notes for Table 1: The group numbers for the performance monitoring private parameter groups preferably will be determined by the I_2O SIG assignee of the inventor. Moreover, the AuthenticationKey may be based on a global timer to guarantee uniqueness. In addition, clearing the locked stage bit after five minutes preferably will not prevent resource contention between multiple applications on the same host since messages from these all have the same initiator TID value. Originally, it was thought that the initiator context field could be used for this purpose. However, some host operating systems control this field. Applications have no control over this field.

Table 2 Performance Monitoring Mode Control Group 0x8001

Group Number	0x8001			
Group Type	Table			
Name	PERFMON_MODE_CONTROL			
Description	A table of mode-specific control parameters for the performance monitoring resources.			
Fieldldx	(r/w)	Field Size	Parameter Name	Description
0	r	1 Byte	Mode	Performance monitoring mode to be controlled, 1-7.
1	r/w	8 Bytes	ModeControl	Bytes 0-3 contain the AuthenticationKey The AuthenticationKey is used to verify that the host application which is attempting to alter the configuration is the one that locked the resources. On writes, this key must be equal to the last authentication key issued by the perfDDM. If equal, the host application's UtilParamsSet message will be processed normally. If not equal to the last issued authentication key, then the UtilSetParams reply message indicates an error. On reads, bytes 3-7 return 0. Bytes 4 - 7 of this field contain the ModeIntervals. The ModeIntervals represents the number of selected sample intervals dedicated to a particular mode when using the simple round-robin; writes to this sub-field cause all modes counter values to be zeroed, if not already done. A flag, counts_zeroed, in perfDDM will track this; it will be set when the first Mode Time is zeroed, and reset when counting is turned on. This will reduce the impact on the overall system that would occur if the Mode Times for more than one mode were altered. This defaults to 10 times the sampling interval.

Note for Table 2: No rowDelete or rowAdd operations need be supported by perfDDM since these fields are present for all modes.

Table 3 Performance Monitoring Mode Data Group 0x8002

Group Number Group Type Name Description		0x8002 Table PERFMON_MODE_DATA A table of data parameters for all counters in each mode. Each row pertains to an individual mode.		
Fieldldx	(r/w)	Field Size	Parameter Name	Description
0	r	1 Byte	Mode	Performance monitoring mode for the data, 1 - 7.
1	r	8 Bytes	CurrTime	Current accumulated value of GTSR register plus rollover bits. This value accumulates over multiple sample intervals until the end of the timeslice is reached. This is updated whenever an interval ends, if the host application disables counting in the middle of an interval, or if the host application requests the data in the middle of an interval. Main use of this is to determine how stale or current the data is when very long interval times are being used. Units are the period of the GTSR clock.
2	r	8 Bytes	SigmaTime	Accumulated time for this mode at end of last completed interval. Units are the period of the GTSR clock.
3	r	8 Bytes	EndingTime	Value of GTSR plus rollover bits at the end of the last completed interval. This is compared to CurrTime to determine the relative currency of the counter data.
4	r	8 Bytes	Counter01	PEC01 counter value at end of last completed interval.
5	r	8 Bytes	Counter02	PEC02 counter value at end of last completed interval.
6	r	8 Bytes	Counter03	PEC03 counter value at end of last completed interval.
7	r	8 Bytes	Counter04	PEC04 counter value at end of last completed interval.
8	r	8 Bytes	Counter05	PEC05 counter value at end of last completed interval.
9	r	8 Bytes	Counter06	PEC06 counter value at end of last completed interval.
10	r	8 Bytes	Counter07	PEC07 counter value at end of last completed interval.

Table 3 cont. Performance Monitoring Mode Data Group 0x8002

Group Number Group Type Name Description		0x8002 Table PERFMON_MODE_DATA A table of data parameters for all counters in each mode. Each row pertains to an individual mode.		
Fieldldx	(r/w)	Field Size	Parameter Name	Description
11	r	8 Bytes	Counter08	PEC08 counter value at end of last completed interval.
12	r	8 Bytes	Counter09	PEC09 counter value at end of last completed interval.
13	r	8 Bytes	Counter10	PEC10 counter value at end of last completed interval.
14	r	8 Bytes	Counter11	PEC11 counter value at end of last completed interval.
15	r	8 Bytes	Counter12	PEC12 counter value at end of last completed interval.
16	r	8 Bytes	Counter13	PEC13 counter value at end of last completed interval.
17	r	8 Bytes	Counter14	PEC14 counter value at end of last completed interval.

Notes for Table 3: SigmaTime and all counter values are initialized to zero. Also, if delta counting is selected, when the performance monitor mode is first entered, Sigma time and all the counter values are zeroed. In cumulative counting, the Sigma time and all of the counter values are not zeroed when the mode is first entered, and when the mode is exited the values in the GTSR and all of the counters are added to the values in this parameter group.

Figure 4 is a flow diagram of a method of operation 500 of the invention. Method 500 may be implemented in a computer readable storage medium containing executable computer program instructions which when executed cause the networking system to perform method 500. Also, method 500 may be implemented in a distributed readable storage medium containing executable computer program instructions which when executed cause an I/O processor to perform method 500.

At initialization 502 of method 500, the software in local memory 38 of I/O processor 210 initializes. This creates a performance monitoring (PMON) storage table in local memory 38. The PMON storage table can store and keep separate the various pieces of information retrieved from PMON unit 64 and placed in that table. Additionally, initializing the software in local memory 38 also causes PMON driver 320 to register as a private driver with RTOS 302 of I/O processor 210 since PMON driver 320 is not a networking type driver or a storage type driver.

In operation, a user of client 300 or client 400 of **Figure 2** initiates a performance monitor application at step 506 that generates a selection screen at visual monitor 306. The selection screen allows the user to select those events on primary PCI bus 16, secondary PCI bus 18, or internal bus 26 for which the user desires to compile data. The user may also specify the time periods that the user desires to see the compiled data at visual monitor 306. In regards to the events on primary PCI bus 16, secondary PCI bus 18, or internal bus 26, the I_2O Architecture divides monitorable events into occurrence events and duration

events. Occurrence events is counted each time the event occurs. For a duration event, a counter counts the number of clocks during which a particular condition or set of conditions is true. A total of ninety-eight events may be monitored, subject to the availability of event counters.

At step 510, the user selects at visual monitor 306 those events on primary PCI bus 16, secondary PCI bus 18, or internal bus 26 for which the user desires to compile data by entering their selection in the selection screen. After selecting those events the user desired monitored, the information entered into the selection screen at visual monitor 306 is sent at step 514 to OSM 300 of host processor 240 as a message request that specifies specific pieces of data from PMON unit 64. OSM 300 relays this message request to RTOS 302 at step 518 without an understanding of whether the message request is for a networking type driver, a storage type driver, or a private driver. However, RTOS 302 does recognize this message request as a request for the PMON driver 320, previously registered as a private driver with RTOS 302.

Using the fields of the three private parameter groups residing in local memory 38 of I/O processor 210, RTOS 302 translates the message request at step 522 into the appropriate parameter of the private group parameters of the invention. Parameters of the private group parameters are set out in Table 1, Table 2, and Table 3 above.

At step 526, RTOS 302 sends this translated request to PMON driver 320. In response to receiving the translated request, PMON driver 320 queries PMON unit 64 at step 530 for the specific

pieces of data requested by the user. The query to PMON unit 64 results in the requested pieces of data being sent to PMON driver 320 at step 534. PMON driver 320, in turn, sends this data to the PMON storage table in local memory 38 at step 538 where the data will be compiled and stored for dispatch to the user at the time periods specified by the user at visual monitor 306 in the selection screen. The data preferably is saved in such a way that another application could be written that would take this data and present it to client 300, for example, in a meaningful fashion.

At the time periods specified by the user in the selection screen, I/O processor 210 sends the compiled performance monitoring data back to the user through RTOS 302 and OSM 300 at step 542. The compiled performance monitoring data may also be directed to other locations within networking system 200 for purposes such as to cause an effect. For example, the data may be sent to an interpreting device that determines whether the server of host system 230 is too hot based on the compiled performance monitoring data. If so, the interpreting device may generate a message that causes an internal fan to turn on.

The exemplary embodiments described herein are provided merely to illustrate the principles of the invention and should not be construed as limiting the scope of the subject matter of the terms of the claimed invention. The principles of the invention may be applied toward a wide range of systems to achieve the advantages described herein and to achieve other advantages or to satisfy other objectives, as well.

CLAIMS

What is claimed is:

1. A method for retrieving performance monitor data from a processor, comprising:

registering a performance monitoring driver as a private driver with a real time operating system (RTOS) of the processor, wherein the performance monitoring driver is coupled to a performance monitoring unit (PMU);

selecting events within the processor to gather data on;

sending the selected events as a message request to the RTOS;

translating the message request into parameters based on a set of private group parameters that are accessible by the RTOS;

sending the message request as a translated request to the PMU;

returning the pieces of data requested by the translated request to the performance monitoring driver; and

sending the pieces of data to a location specified in the message request.

2. The method of claim 1, further comprising:

prior to registering the performance monitoring driver, initializing software in memory of the processor.

3. The method of claim 1, further comprising:

subsequent to registering the performance monitoring driver, initiating a performance monitor application that generates a selection screen at a visual monitor coupled to the processor through a host processor, wherein selecting events within the processor on which to gather data includes selecting the events at

the selection screen.

4. The method of claim 3, wherein selecting events within the processor on which to gather data includes selecting one of ninety eight events arranged in connection with the selection screen.

5. The method of claim 1, wherein sending the selected events as a message request to the real time operating system includes sending the message request through an operating system specific module of a host processor.

6. The method of claim 1, wherein sending the translated request to the performance monitoring unit includes sending the translated request through the performance monitoring driver.

7. The method of claim 1, wherein the set of private group parameters includes at least one of (i) control parameters for hardware-based performance monitoring resources, (ii) mode-specific control parameters for a performance monitoring resource, and (iii) data parameters for at least one mode in one counter.

8. The method of claim 7, wherein the set of private group parameters includes at least one of the following parameters: AdjustedSample, Control, Counter01, Counter02, Counter03, Counter04, Counter05, Counter06, Counter07, Counter08, Counter09, Counter10, Counter11, Counter12, Counter13, Counter14, CurrentMode, CurrTime, EndingTime, Interval, LockControl, MaxAlgorithm, MaxMode, MinSampleInterval, MinSampleUnits, Mode,

ModeControl, NumCounters, PerfHWType, SampleInterval, SigmaTime, and Status.

9. The method of claim 1, further comprising:

subsequent to registering the performance monitoring driver, generating performance monitoring storage tables within memory of the processor.

10. The method of claim 9, further comprising:

subsequent to returning the pieces of data requested by the translated request to the performance monitoring driver, sending the pieces of data to the performance monitoring storage tables.

11. The method of claim 1, wherein sending the pieces of data to a location specified in the message request further includes sending the pieces of data at a time period specified in the message request.

12. The method of claim 11, wherein the location specified in the message is a client coupled to the processor through a network.

13. The method of claim 11, wherein the location specified in the message is a client coupled to the processor through a host processor.

14. The method of claim 11, wherein the location specified in the message is a means for determining whether the server of a host system is too hot based on the pieces of data returned from the performance monitoring unit.

15. The method of claim 14, wherein the means for determining is an interpreting device, the method further comprising:

generating a message in the interpreting device that causes a fan internal to the host system to turn on in response to the pieces of data returned from the performance monitoring unit.

16. In a networking system including a host system having a host processor coupled to an processor through a peripheral components interconnect bus, and including a first client coupled to the host system and a second client coupled to the host system through network lines, a computer readable storage medium containing executable computer program instructions which when executed cause an processor to perform a method comprising:

registering a performance monitoring driver as a private driver with a real time operating system of the processor, wherein the performance monitoring driver is coupled to a performance monitoring unit;

selecting events within the processor on which to gather data;

sending the selected events as a message request to the real time operating system;

translating the message request into parameters based on a set of private group parameters that are accessible by the real time operating system;

sending the message request as a translated request to the performance monitoring unit;

returning the pieces of data requested by the translated request to the performance monitoring driver; and

sending the pieces of data to a location specified in the message request.

17. The computer readable storage medium of claim 16, wherein the set of private group parameters includes at least one of (i) control parameters for hardware-based performance monitoring resources, (ii) mode-specific control parameters for a performance monitoring resource, and (iii) data parameters for at least one mode in one counter.

18. The computer readable storage medium of claim 17, the method further comprising:

subsequent to registering the performance monitoring driver, generating performance monitoring storage tables within memory of the processor; and

subsequent to returning the pieces of data requested by the translated request to the performance monitoring driver, sending the pieces of data to the performance monitoring storage tables.

19. A distributed readable storage medium containing executable computer program instructions which when executed cause an processor to perform a method for retrieving performance monitor data from the processor, the method comprising:

registering a performance monitoring driver as a private driver with a real time operating system of the processor, wherein the performance monitoring driver is coupled to a performance monitoring unit;

selecting events within the processor on which to gather data;

sending the selected events as a message request to the real time operating system;

translating the message request into parameters based on a set of private group parameters that are accessible by the real time operating system;

sending the message request as a translated request to the performance monitoring unit;

returning the pieces of data requested by the translated request to the performance monitoring driver; and

sending the pieces of data to a location specified in the message request.

20. The distributed readable storage medium of claim 19, wherein the set of private group parameters includes at least one of (i) control parameters for hardware-based performance monitoring resources, (ii) mode-specific control parameters for a performance monitoring resource, and (iii) data parameters for at least one mode in one counter.

21. The distributed readable storage medium of claim 20, the method further comprising:

subsequent to registering the performance monitoring driver, generating performance monitoring storage tables within the memory of the processor; and

subsequent to returning the pieces of data requested by the translated request to the performance monitoring driver, sending

the pieces of data to the performance monitoring storage tables.

ABSTRACT

The present invention relates to retrieving performance monitor data from an I/O processor. A performance monitoring driver coupled to a performance monitoring unit is registered as a private driver with a real time operating system of the I/O processor. Events within the I/O processor are selected on which to gather data. The selected events are sent as a message request to the real time operating system. The message request is translated into the appropriate parameters based on a set of private group parameters that are accessible by the real time operating system. The message request is sent as a translated request to the performance monitoring unit. The pieces of data requested by the translated request are returned to the performance monitoring driver. The pieces of data then are sent to a location specified in the message request.

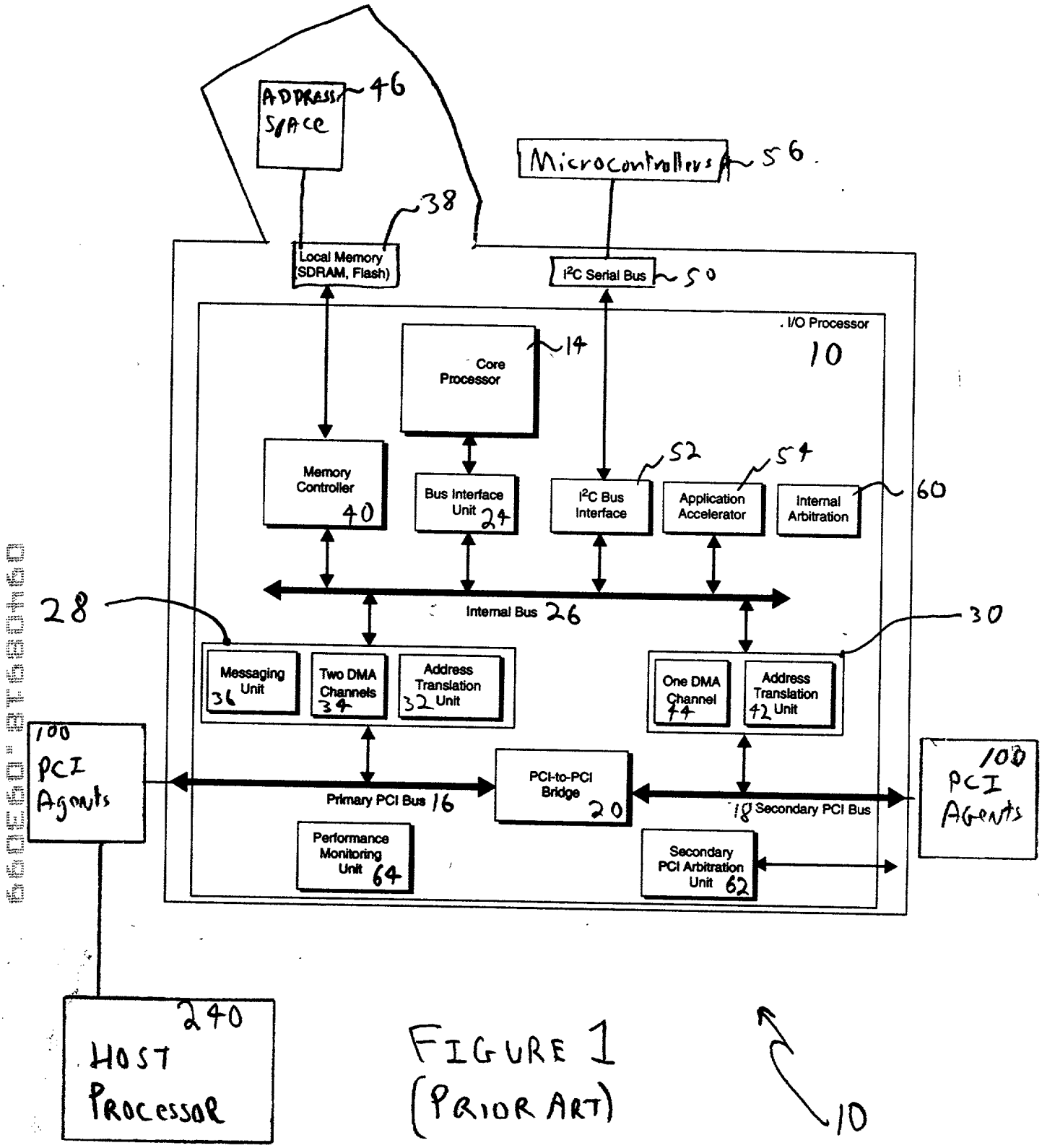

FIGURE 1
(PRIOR ART)

10

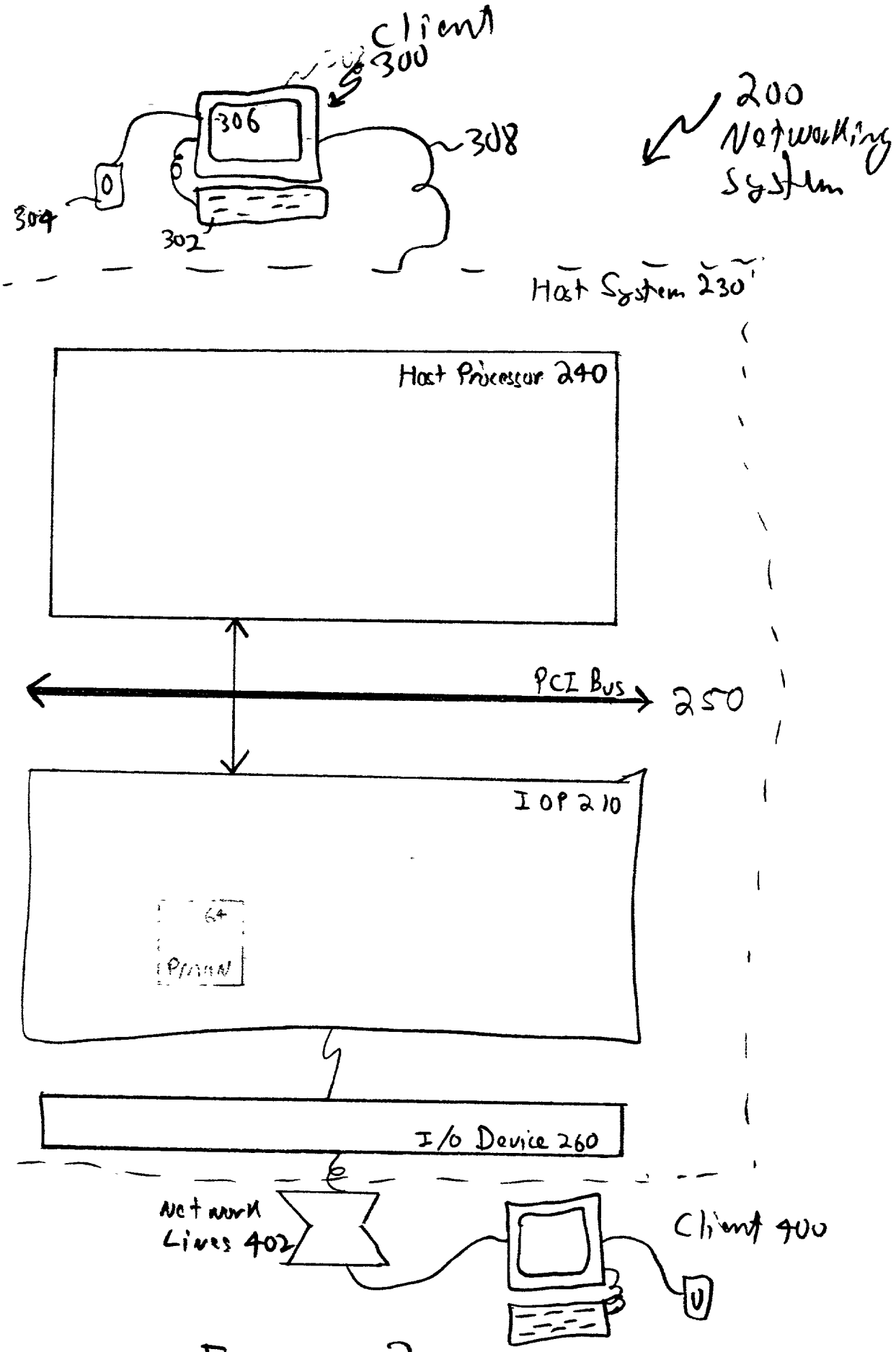
Client
300
306
308
304
302
200
Networking
System
Host System 230
Host Processor 240
PCI Bus
250
IOP 210
64
PMMN
I/O Device 260
Network
Lines 402
Client 400

FIGURE 2

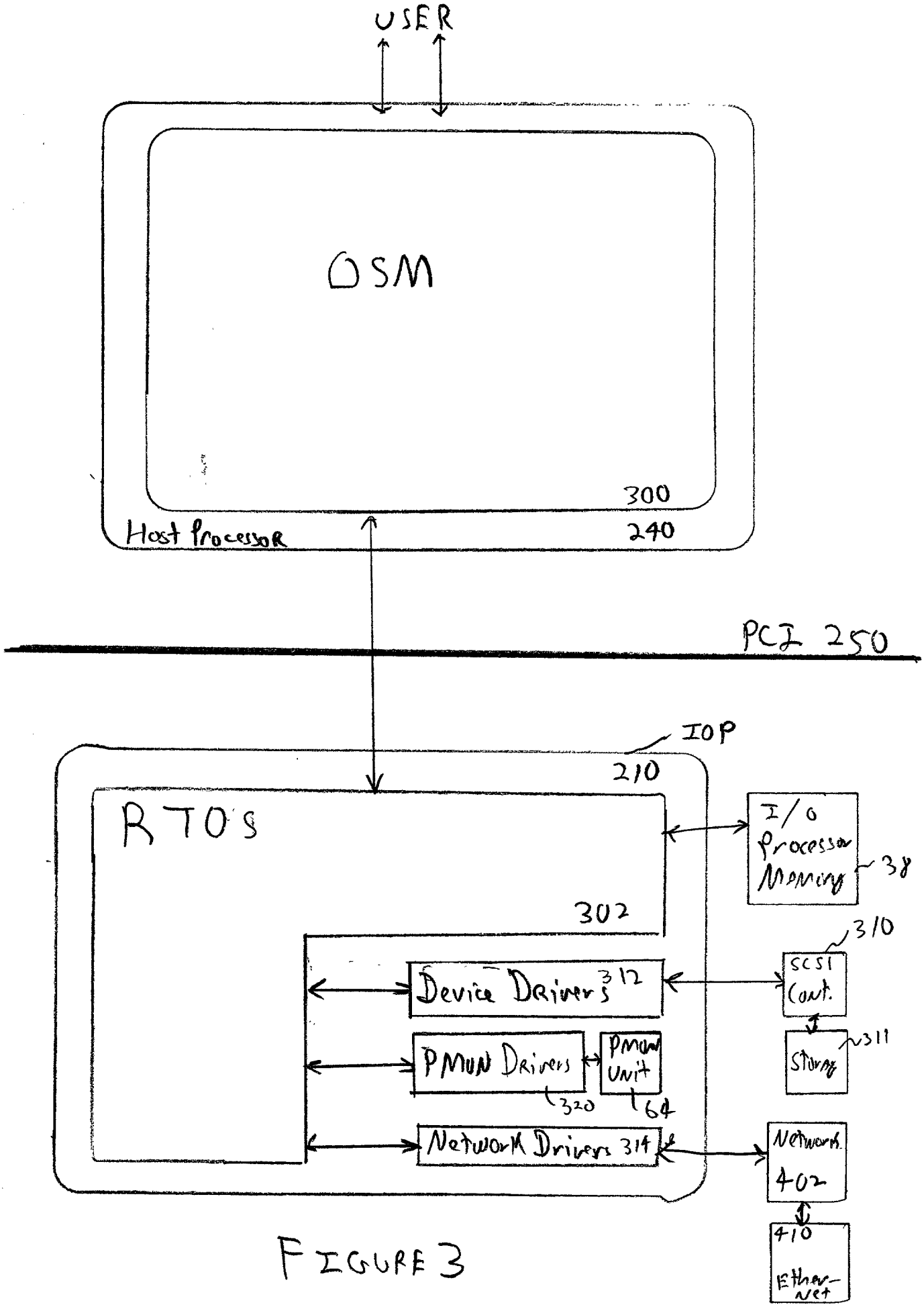
USER
OSM
300
Host Processor
240
PCI 250
IOP
210
RTOS
I/O Processor Memory
38
302
310
SCSI Cont.
Device Drivers 312
Storage
311
PMON Drivers
320
PMON Unit
64
Network Drivers 314
Network 402
410
Ethernet

FIGURE 3

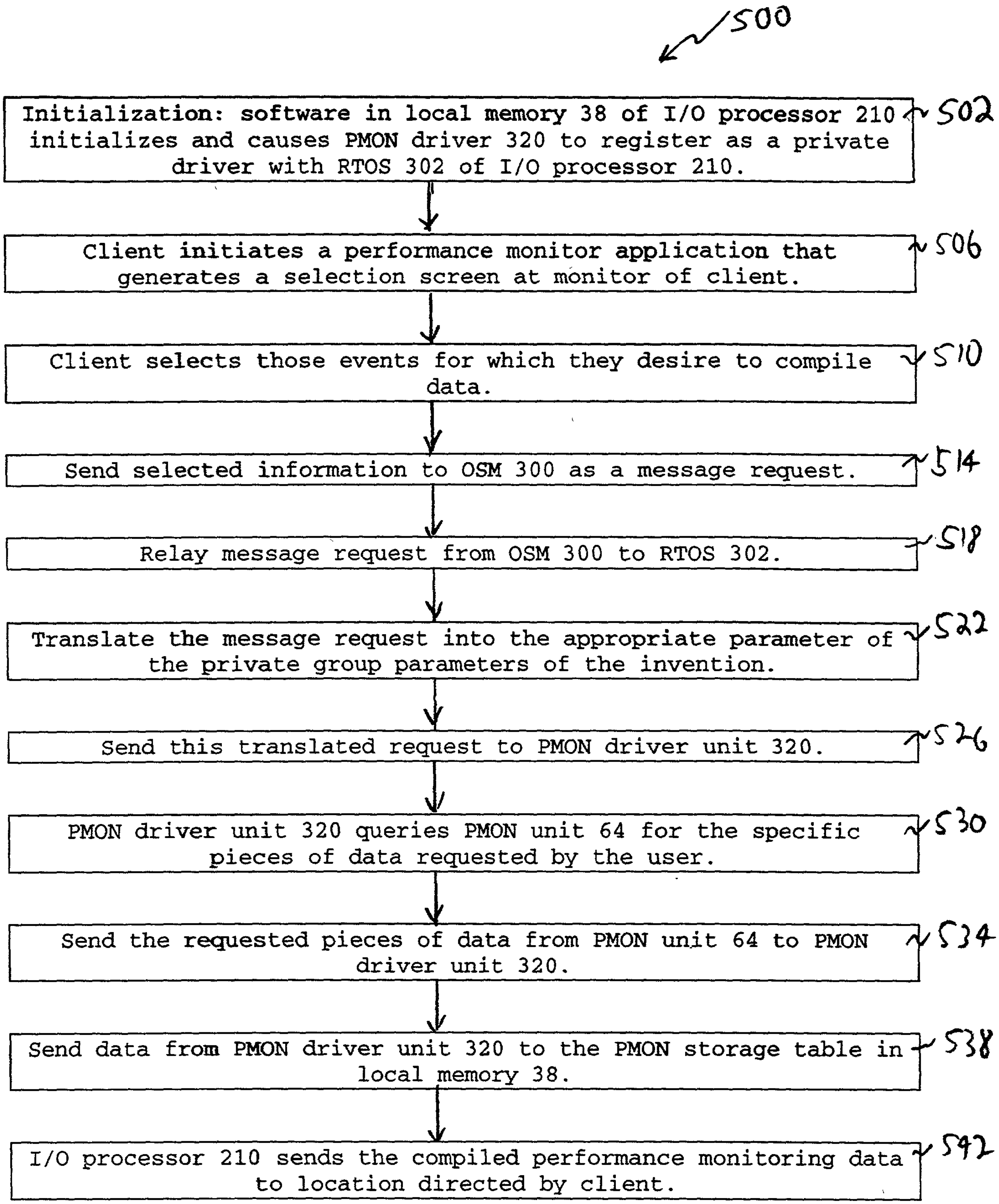
500
Initialization: software in local memory 38 of I/O processor 210 initializes and causes PMON driver 320 to register as a private driver with RTOS 302 of I/O processor 210.
502
Client initiates a performance monitor application that generates a selection screen at monitor of client.
506
Client selects those events for which they desire to compile data.
510
Send selected information to OSM 300 as a message request.
514
Relay message request from OSM 300 to RTOS 302.
518
Translate the message request into the appropriate parameter of the private group parameters of the invention.
522
Send this translated request to PMON driver unit 320.
526
PMON driver unit 320 queries PMON unit 64 for the specific pieces of data requested by the user.
530
Send the requested pieces of data from PMON unit 64 to PMON driver unit 320.
534
Send data from PMON driver unit 320 to the PMON storage table in local memory 38.
538
I/O processor 210 sends the compiled performance monitoring data to location directed by client.
542

Figure 4

Attorney's Docket No.: 042390.P6518

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION (FOR INTEL CORPORATION PATENT APPLICATIONS)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

RETRIEVING I/O PROCESSOR PERFORMANCE MONITOR DATA

the specification of which

[X] is attached hereto.
[ ] was filed on _____ as
United States Application Number _____
or PCT International Application Number _____
and was amended on _____ .
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s):

APPLICATION NUMBER	COUNTRY (OR INDICATE IF PCT)	DATE OF FILING (day, month, year)	PRIORITY CLAIMED
			☐ No ☐ Yes
			☐ No ☐ Yes
			☐ No ☐ Yes

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

APPLICATION NUMBER	FILING DATE

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

APPLICATION NUMBER	FILING DATE	STATUS (ISSUED, PENDING, ABANDONED)

I hereby appoint BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN, a firm including: William E. Alford, Reg.37,764; Farzad E. Amini, Reg. No. 42,261; Amy M. Armstrong, Reg. No. 42,265; Aloysius T. C. AuYeung, Reg. No. 35,432; William Thomas Babbitt, Reg. No. 39,591; Carol F. Barry, Reg. No. 41,600; Jordan Michael Becker, Reg. No. 39,602; Bradley J. Bereznak, Reg. No. 33,474; Michael A. Bernadicou, Reg. No. 35,934; Roger W. Blakely, Jr., Reg. No. 25,831; Gregory D. Caldwell, Reg. No. 39,926; Ronald C. Card, Reg. No. P44,587; Thomas M. Coester, Reg. No. 39,637; Michael Anthony DeSanctis, Reg. No. 39,957; Daniel M. De Vos, Reg. No. 37,813; Robert Andrew Diehl, Reg. No. 40,992; Matthew C. Fagan, Reg. No. 37,542; Tarek N. Fahmi, Reg. No. 41,402; James Y. Go, Reg. No. 40,621; James A. Henry, Reg. No. 41,064; Willmore F. Holbrow III, Reg. No. 41,845; Sheryl Sue Holloway, Reg. No. 37,850; George W Hoover II, Reg. No. 32,992; Eric S. Hyman, Reg. No. 30,139; Dag H. Johansen, Reg. No. 36,172; William W. Kidd, Reg. No. 31,772; Erica W. Kuo, Reg. No. 42,775; Michael J. Mallie, Reg. No. 36,591; Paul A. Mendonsa, Reg. No. 42,879; Darren J. Milliken, Reg. No. 42,004; Thinh V. Nguyen, Reg. No. 42,034; Dennis A. Nicholls, Reg. No. 42,036; Kimberley G. Nobles, Reg. No. 38,255; Lisa A. Norris, Reg. No. P44,976; Daniel E. Ovanezian, Reg. No. 41,236; Babak Redjaian, Reg. No. 42,096; William F. Ryann, Reg. No. 44,313; James H. Salter, Reg. No. 35,668; William W. Schaal, Reg. No. 39,018; James C. Scheller, Reg. No. 31,195; Jeffrey S. Smith, Reg. No. 39,377; Maria McCormack Sobrino, Reg. No. 31,639; Stanley W. Sokoloff, Reg. No. 25,128; Judith A. Szepesi, Reg. No. 39,393; Vincent P. Tassinari, Reg. No. 42,179; Edwin H. Taylor, Reg. No. 25,129; George G. C. Tseng, Reg. No. 41,355; Joseph A. Twarowski, Reg. No. 42,191; Lester J. Vincent, Reg. No. 31,460; John Patrick Ward, Reg. No. 40,216; Charles T. J. Weigell, Reg. No. 43,398; Kirk D. Williams, Reg. No. 42,229; James M. Wu, Reg. No. P45,241; Steven D. Yates, Reg. No. 42,242; Ben J. Yorks, Reg. No. 33,609; and Norman Zafman, Reg. No. 26,250; my attorneys; and Justin M. Dillon, Reg. No. 42,486, Edwin A. Sloane, Reg. No. 34,728; and John F. Travis, Reg. No. 43,203; my patent agents, with offices located at 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025, telephone (310) 207-3800, and Alan K. Aldous, Reg. No. 31,905; Robert D. Anderson, Reg. No. 33,826; Joseph R. Bond, Reg. No. 36,458; Richard C. Calderwood, Reg. No. 35,468; Jeffrey S. Draeger, Reg. No. 41,000; Cynthia Thomas Faatz, Reg No. 39,973; Sean Fitzgerald, Reg. No. 32,027; Seth Z. Kalson, Reg. No. 40,670; David J. Kaplan, Reg. No. 41,105; Charles A. Mirho, Reg. No. 41,199; Leo V. Novakoski, Reg. No. 37,198; Naomi Obinata, Reg. No. 39,320; Thomas C. Reynolds, Reg. No. 32,488; Mark Seeley, Reg. No. 32,299; Steven P. Skabrat, Reg. No. 36,279; Howard A. Skaist, Reg. No. 36,008; Steven C. Stewart, Reg. No. 33,555; Raymond J. Werner, Reg. No. 34,752; and Charles K. Young, Reg. No. 39,435; my

Send correspondence to Vincent P. Tassinari, Reg. No. 42,179, BLAKELY, SOKOLOFF, TAYLOR &
(Name of Attorney or Agent)
ZAFMAN LLP, 12400 Wilshire Boulevard, 7th Floor, Los Angeles, California 90025 and direct telephone calls to Vincent P. Tassinari, Reg. No. 42,179, (310) 207-3800.
(Name of Attorney or Agent)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole/First Inventor (given name, family name) Susan C. Kromenaker

Inventor's Signature Susan C. Kromenaker Date 9/30/99

Residence Chandler, Arizona (City, State) Citizenship U.S.A. (Country)

P. O. Address 4909 W. Joshua Blvd. #2112

Chandler, Arizona 85226 U.S.A.

Full Name of Second/Joint Inventor (given name, family name) Mark L. Brown

Inventor's Signature _____ Date 9/30/99

Residence Gilbert, AZ (City, State) Citizenship U.S.A. (Country)

P. O. Address 529 E Horseshoe Ave

Gilbert, AZ 85296

Full Name of Third/Joint Inventor (given name, family name) Linda M. Roberts

Inventor's Signature Linda M Roberts Date 9-30-99

Residence Phoenix, Arizona (City, State) Citizenship U.S.A. (Country)

P. O. Address 5031 East Vaughn Drive

Phoenix, Arizona 85044 USA

Full Name of Fourth/Joint Inventor (given name, family name) William C. Arthur, Jr.

Inventor's Signature William C. Arthur Date 9/30/99

Residence Pheonix, Arizona (City, State) Citizenship U.S.A. (Country)

P. O. Address 14813 S. 24th Street

Pheonix, Arizona 85048 U.S.A.

Full Name of Fifth/Joint Inventor (given name, family name) _____

Inventor's Signature _____ Date _____

Residence _____ (City, State) Citizenship _____ (Country)

P. O. Address _____